Culturally Embedded Computing

Culturally embedded computing explicitly situates embedded computing in society, individual experience, culture, and history. Based on this new emphasis, five projects explore alternatives to traditional human-computer interaction design.

Phoebe Sengers, Joseph Kaye, Kirsten Boehner, Jeremiah Fairbank, Geri Gay, Yevgeniy Medynskiy, and Susan Wyche
Cornell University

Imagine a world without architects, where only engineers construct buildings. With a keen eye toward functionality, these engineers would make sure the buildings were sound, but something would be lacking. People would miss the richness of architecture—the designed connection to their lives, history, and culture. The designed experience of these buildings would be irrelevant to their social and personal concept of buildings. Yet this is the world researchers are inadvertently creating with ubiquitous computing.

Most discussions about ubiquitous computing rely on an engineering perspective, centering on the fact that computing is leaving the desktop. But in leaving the laboratory and workplace, computing is crossing not only physical but also social and cultural boundaries. It's becoming embedded not only in physical environments but also in culture, society, and history. Designing and building these new technologies requires more than simply building and understanding hardware and software. It also requires analyzing and incorporating the stories, meanings, and social networks that these devices engage.

Alternatives to pure engineering approaches to ubiquitous computing are emerging in digital arts and design research that encompass social and cultural meanings and implications.[1,2] Our approach rests primarily on Philip Agre's notion of critical technical practice,[3] in which practices of technology design incorporate critical, philosophical self-reflection to generate new technical algorithms and concepts. Whereas Agre's goals in critical technical practice focus mainly on improving technology, our design team includes several researchers building technical systems for, and commenting on, technology's cultural and historical situation.[4–6] In this spirit, we build technologies to change not only what people can do but also the way they think about technology.

Our group is interdisciplinary—with researchers from computer science, user interface design, social science, cultural studies, architecture, and product design—all interested in computing in everyday life. Under the umbrella of the Cornell Information Science program, project collaborations gave rise to what we call *culturally embedded computing*.

Defining culturally embedded computing

In mainstream human-computer interaction (HCI), the primary goal is generally to develop a product or prototype that's successful regardless of its cultural, social, or historical context. Does it do what it was supposed to do? Is it user friendly and accessible? In culturally embedded computing, we begin by examining how the technology is emblematic of its cultural context. Why do we want a product or prototype to work in a

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certain way in the first place? Why are specific design decisions made? What alternatives should we consider? How should our design change on the basis of these insights?

Shifting perspectives this way requires taking methodologies that primarily focus on technology alone and adapting them so that they focus on technology in its social and cultural context. Three major themes guide our work:

- *Reflective design.* Some of our products are things to use; some are things to think with. The latter might have little practical use but can encourage reflection on technology, its situated meanings in people's lives, and our own role as researchers and designers.
- *Focus on personal experience.* In developing ubiquitous systems, we focus on the way interactive systems shape people's experiences of their everyday lives.
- *Contextualizing technology in culture rather than other technology.* In technical research, new technologies generally build on previous technical advances. Our research also focuses on technology's historical, cultural, and social implications.

As we discuss examples and implications of these themes, we describe five projects at various stages of development: Cultural Switches, the Influencing Machine, Miro, iFortune, and Trigger Spray Bottles. Each project lets us illuminate different aspects of reflective design, personal experience, and contextualizing technology in culture.

Reflective design: Cultural Switches

Reflective design involves building systems that promote reflection on a device's design, including its use, the user, the designer, and surrounding social and cultural practices. In short, it's design for thinking critically about design. One strategy for reflective design is for subjects to collaborate as researchers exploring relationships between technology, users, designers, and culture. Therefore, we aim to create experiences of technology that are immediate and nonthreatening so that people feel confident in their roles as experts.

Cultural Switches was a series of studies based on HCI user studies, but focusing on how people interpret technology rather than on developing or evaluating a specific technical system. A typical user study would observe and interview people working with some technology and then analyze the findings to draw conclusions. However, this study was not about building better technology; it was about how people perceive and work with technology. It was thus important to encourage participants to engage in the analysis process with us—to make meaning out of their own responses to the technology.

In our work, the technology's ultimate design is secondary; the primary focus is the design choices and resulting implications.

These studies focused on the switch, the simplest form of technology imaginable—technically, simply a bit. From light switches to on/off switches in everyday appliances, the switch represents the meeting ground between people as users and technology as designed systems. This artifact let us focus on the proliferation of cultural meaning around a technically trivial device. In one exercise within this larger study, we asked participants to build their own mockups of switches with craft supplies. By making participants designers, we hoped not only to underscore their expertise but also to inspire reflection on the meaning behind certain design decisions and the resulting implications for technology consumers and designers.

We encouraged six participants—all affiliated with Cornell, mostly students—to build either an improved version of a switch they currently use or a switch for some new, speculative functionality. Once the participants constructed the switches, we reflected with them about their design decisions. One participant built a weather switch: similar to a thermostat yet letting the user change the weather. Another built an enhanced dimmer switch providing tactile feedback. A third participant created a commentary switch, with a humorous intention, in the form of a bright red "switch to socialism."

In participatory design, users inform the design process to build technology that fits their needs. In our work, the technology's ultimate design is secondary; the primary focus is the design choices and resulting implications. Therefore, our success metrics were not whether participants built good switches, but whether the exercise of building switches provided a useful stimulus for encouraging reflection on designed systems. In the position of designers, participants spoke with authority about what type of functionality they chose to fulfill the switch's purpose, and its possible implications. For example, the construction of the weather switch led to conversations about what it means to build weather-control technology: What would happen if everyone in Ithaca had a weather switch? Would

every day be sunny, or would more complex patterns of use emerge?

We learned that open-ended questions produce lengthy and rich responses. Starting the interviews with "Tell us what you did" and ending with "Is there anything else you'd like to tell us?" produced more interesting discussions than asking specific detailed questions. Managing our conversation as an open-ended exchange among equals was more difficult than a prestructured interview but enabled new reflection on design: "I didn't realize this until after we started talking. ..." From this experience, we understand our role as cultural researchers to involve creating interesting stimuli and then backing off to give participants space to create and reflect on their own interpretations.

We identified two critical factors enabling reflective design experiences. The first was the approachability of the artifact—in this case, the switch. The second was the level of engagement possible. For a simple device that generally enables two states, on or off, the switch artifact still provided room for critical discussion about what these states would control and why, how to represent them, whether there are in-between states, and how the design of technology itself is a form of communication.

We now consider these two factors from another perspective. Whereas the Cultural Switches study used a noncomputational device as a prop for reflection on design, the Influencing Machine and Miro studies enable reflective design through constructing and deploying actual computational devices.

Focus on personal experience

The Cultural Switches project rethinks the role of user studies from straight technology evaluation toward sociocultural research. Our goal was not only to improve our understanding of people and technology but also to encourage participants to rethink their own experiences in light of their participation. The next two projects, the Influencing Machine and Miro, build on this approach and expand the concept of personal experience involved in designing computational systems.

The Cultural Switches project rethinks the role of user studies from straight technology evaluation toward sociocultural research.

Developing computational systems to respond to a user's emotional experience, also called *affective computing*, is one way to enhance technology design for more personal experience.[7] However, existing affective-computing approaches often stress informatics, treating emotion as computational bits to measure, structure, and formalize, rather than something to experience. In culturally embedded computing, we're less interested in formal models of emotion than in relatively enigmatic human experiences of emotion.

With the Influencing Machine and Miro, we explore the design of technical devices for nonformalized, and potentially nonformalizable, aspects of human experience. In other words, we use affective computing not to reason about people's emotional states but to create intuitive experiences and interpretations of affect.

The Influencing Machine: Exploring affect as enigma

The Influencing Machine encourages reflection on the intersection between emotion and technology, and it probes the possibilities of affective computing.[8] Before participants began working with the Influencing Machine, we told them the experience had something to do with emotion, but we gave them no other instructions other than to explore for as long as they wished. Upon entering the room, people saw a display of childlike scribbling projected on the wall: jagged lines, circles, spirals in simple colors, each building up and fading away. A large wooden mailbox sat on a table surrounded by various postcards of emotionally evocative art. Participants fed postcards into the mailbox, triggering unusual sounds and causing changes in the speed, color, and form of the drawings on the wall. Typically, participants became puzzled, experimented with different cards, and discussed theories of how the system might be working, as well as whether, how much, and in what respect it might be emotional.

The Influencing Machine does in fact respond to the postcards' emotional content. Each postcard had a barcode that modified the machine's internal emotional model. The model includes 22 emotions, mapped into 11 pairs of opposites, such as happy/sad or aggressive/passive. Postcards trigger alterations in the emotional state, which in turn drive the graphical display and sound output. Importantly, we did not design the changes to directly communicate the computer's emotions, but we deliberately multivalenced them and made them enigmatic to encourage reflection about emotion and the role computing could play in it. The Influencing Machine is not transparently readable; it demands reflective interpretation.

In evaluating the Influencing Machine,[9] we saw that some people (particularly

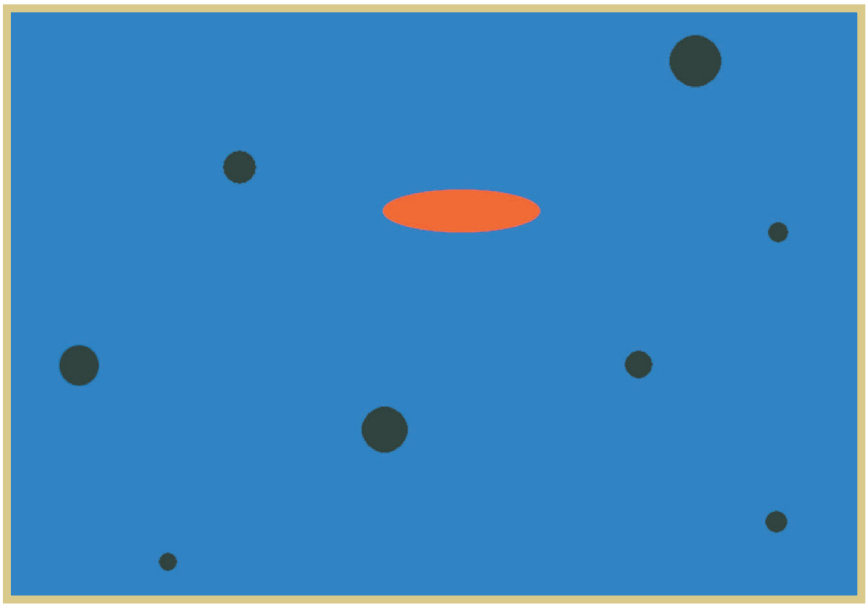

Figure 1. Screen shot of the Miro display projected onto the wall.

those older and less computer literate) felt intimidated by this demand, whereas others engaged enthusiastically in debates about the machine and affective computing. For example, one group of subjects—a married couple and a friend of the wife—quarreled about whether the postcards were influencing the machine. During this argument, the wife noted the computer under the table and asked the man whether this computer was connected to the mailbox into which they had been inserting postcards. She seemed to imply that if it were connected, the Influencing Machine was just a computer, not a machine that emotions could influence. Apparently, she thought that a computer must be predictable and therefore couldn't be what her husband's theories of its emotional reactions would imply.

The Influencing Machine is culturally embedded as a boundary object in which technical algorithms are structured to trigger cultural interpretations. By encouraging users to reflect on their personal experiences, it lets them participate in a cultural commentary on the relationship between machines and emotions in a computational age. One unexpected result, though, highlighted not what groups said about the machine but the way in which interaction with the machine revealed their relationships to one another. In the group mentioned previously, for example, the wife belittled and ignored every suggestion by her husband—who was on the right track—while the friend attempted to remain neutral. Frequently, the machine acted as a social probe, and the social dynamics the machine triggered were far more interesting to the designers and evaluators than the performance of the system itself.

In the process, we began to see that devices are useful and interesting not necessarily on their own merits but in the context of people's relationships and situations. This observation suggested the notion of designing devices for social experiments—that is, to trigger emergent social interactions and interpretations. This led to the design of Miro.

Miro: Reflections on collective experience

The Miro installation senses, displays, and influences the collective emotions and activity level of a communal space. Whereas the Influencing Machine focuses on interpretation of machine emotion in a contained situation, Miro focuses on a social group's ongoing emotional experiences in an open office environment. There are various examples of ambient computing and pervasive computing in office environments that provide aesthetic displays of quantitative information, such as weather reports, stock market prices, and Ethernet traffic.[10] However, the information we wanted to portray, emotional climate, is qualitative, ambiguous, and nondiscrete.

We also wanted to bridge between technology for providing information and technology as a canvas for creative expression. In the workplace, technology to improve efficiency is common, whereas technology for personal or artistic experience is not. We envisioned an application for both deducing information and evoking interpretations of affect. Our measures of success would therefore concern how people worked with the display and what meaning they attributed to it. We were specifically interested in whether people perceived the display as a tool informing them about affect in the office or more as an evocative experience of affect.

We installed Miro in the Information Science building, a semi-open office environment housing about 30 people, most of whom are not affiliated with our group. Initial designs were based on a survey asking residents how they currently read the affective climate in the office and how they might like this information augmented. For the display, we animated an image based on artist Joan Miró's *Blue*, and projected this in an office common space. In the animated translation, the red swath of paint moved through the middle of the picture like an agent while the number of black spots varied and the background morphed into different textures and colors (see Figure 1).

Three measurement tools gathered input:

- A sound card estimated activity levels
- An emotion survey available on laptops around the building solicited

answers to the question, "How are you feeling?"
- Personal emotion journals kept by participants for a week before the installation established the display's baseline behavior

We didn't propose an exact science of measuring emotions. Instead, we hoped to portray deltas in the affective climate and leave interpretation and attribution of emotion and activity open. Therefore, we derived the baseline behavior from the emotion journals and modulated this behavior with the dynamic input from the sound level and the survey responses.

During observations of the prototype installation, we often found people just watching the display, talking about it in groups, and venturing interpretations to passersby. Some people constructed complex meaning in the simple display—one respondent said the red swath moving through the picture was a tear in the emotional climate showing the hidden side of the office's public face. However, most people wanted simple one-to-one correspondences between input and output and approached the display like a game to figure out. Participants persistently asked the researchers for the "right" interpretation. In other words, the expression of Miro was rich, but its readability was shallow. When people approached the display as a tool for improving awareness of affect, they were somewhat frustrated with not being able to match input to output. However, when people approached the display as art, they were more comfortable with its openness to interpretation.

Two aspects of Miro's design are important to consider as we look at its implications for our larger research efforts. First, because the participants in this experience were colleagues, they had prior knowledge of one another that informed their interpretations. We often overheard them querying each other about what might be happening to influence the display, such as an imminent deadline. Miro wasn't a mirror that reflected dynamics, but rather a catalyst for stimulating reflection and discussion about the current climate. Miro's role as catalyst partly depended on its use by people with existing relationships. Second, it wasn't only the display that created this awareness of affect. The entire design process—from asking for initial input on measuring the collective emotions and activity level to the baseline emotion journals to the emotion surveys—drew attention to affect. As one participant commented, "I just like the fact that someone is asking me how I feel, even if it is a computer." The eventual display was a stimulus for conversation, but it was only one part of the experience evoked by the entire design process.

Whereas we built Cultural Switches to encourage reflection on the process and results of conceptual design, we built the Influencing Machine and Miro expressly to encourage reflection—in this case, reflection on technology as part of a rich nonformalizable experience. In other words, these projects are examples of using culturally embedded computing to question what aspects of experience people consider computational and how this computational capability can create representations open to rich interpretation.

Examining the history of domestic technology, home economics, and gender roles is particularly important to our work.

Contextualizing technology in culture

So far, we've explored reflective design and personal experience. However, these are incomplete without recognizing that technology is situated in culture and history. In particular, we need to understand ubiquitous computing in the context of the Western consumer culture, which prioritizes mass production and efficiency as easily quantifiable metrics over less-measurable aspects such as enjoyment and spirituality.[11]

The consumer culture is particularly pertinent to ubiquitous computing for several reasons. First, ubiquitous devices often focus particularly on consumer applications rather than laboratory or workplace ones. Second, the rise of the consumer culture is precisely why everyday technologies (including noncomputational ones) have become readily available. So, analysis of consumer culture can throw particular light on the nature of everyday technologies. Finally, many concepts for domestic ubiquitous computing stem from a vision of an idealized middle-class American or Western European home, a vision largely shaped by the consumer culture.

The iFortune and Trigger Spray Bottles projects critique consumer culture through their design. Examining the history of domestic technology, home economics, and gender roles is particularly important to our work. These two projects question and rethink the role of technology in the home.

iFortune: Integrating functionality and experience in the kitchen

iFortune rethinks the role of functionality in kitchen appliances. Historically, technology has entered the kitchen

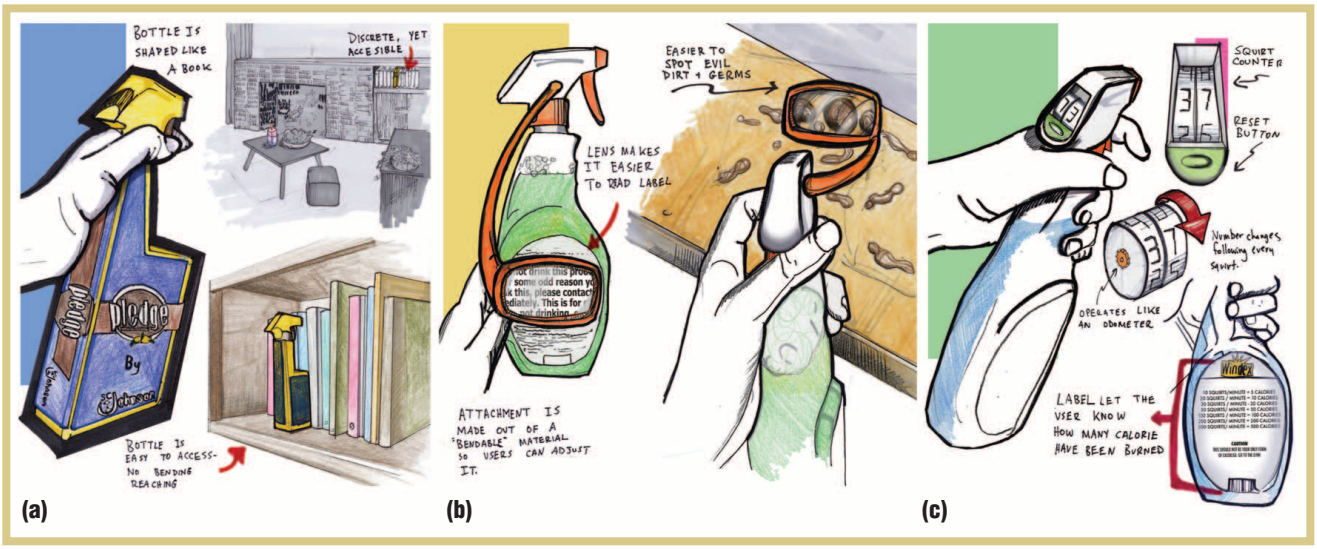

Figure 2. Three designs challenging existing cleaning devices: (a) Book Bottles; (b) the Bottle Monocle; (c) the Calorie-Counter Trigger.

as tools for greater efficiency or convenience.[12] In contrast, we propose a playful kitchen appliance to help restore low-key spirituality to daily life. The inspiration for this project came from tasseography, the ancient practice of reading tea leaves or coffee grounds. In this practice, ambiguous readings leave interpretation up to the one drinking the tea or coffee much the way a newspaper horoscope might do.

iFortune, which resembles a small shrine, takes a digital photograph of the bottom of the cup when that cup is inserted into the device. The system then matches features with patterns in a stored library drawn from tasseography books, and it generates a fortune on a strip of paper. The design draws from open-ended surveys of 25 Cornell students, which revealed a surprisingly high level of attachment toward and guilt about the participants' cups. As one student commented (in the voice of his coffee cup): "I get used every morning … and then my owner runs off to class, completely forgetting to wash me … and there I stand, all alone, forgotten, forlorn, and unwashed."

The initial design of iFortune has produced an interesting debate about the issue of functionality. Some members of the research team believed the device's critique works best if it integrates a useful function such as washing your cup after reading your fortune. The participant responses seem to validate this idea; like the student just quoted, many of them referred to the necessity of keeping their cups clean. Other members of the design team argued that requiring the machine to also perform as a conventional appliance would diminish its capacity as a critical device. They suggested that a spiritual or playful activity could be considered as functional as washing one's cup. We look forward to exploring this debate and seeing how people interpret iFortune over a longer period of use.

iFortune questions what people assume a machine can and cannot do. It serves as a call and medium for reintroducing spirituality to the kitchen. Because it can reside alongside other countertop products, it also falls within domestic culture. Moreover, it questions the equation of functionality with efficiency embedded in such devices and suggests a space for playful appliances. It also connects ubiquitous devices with the history of the home. The next project, Trigger Spray Bottles, further explores this historical connection.

Trigger Spray Bottles: Redesigning culturally embedded cleaning technology

Trigger Spray Bottles is part of a larger initiative to understand how older people clean their homes and to develop products that meet their needs. This project revolves around everyday technology in the form not of ubiquitous computing but of everyday cleaning devices and practices. In so doing, it situates ubiquitous computing in the context of a long history of household devices.

Just as the Cultural Switches project used a single artifact to focus attention on people's relationship with technology, this project used a single device, the everyday trigger spray bottle, to understand the relationship between aging, domestic space, and cleaning products and practices. This research included interviews with 18 subjects (65 and older) about how they clean their homes. These visits inspired three product ideas, illustrated in Figure 2, that challenge assumptions and misconceptions of the elderly and their cleaning practices.

One common theme uncovered was the subjects' frustration about accessing cleaning products. Most people stored their cleaning products in cabinets that required either bending over or stretching

beyond arm's reach, actions increasingly difficult with encroaching age. This observation inspired the design of Book Bottles (see Figure 2a). These trigger-spray bottles become a discrete but accessible part of the domestic environment.

Another accessibility issue was the small print for directions and safety instructions on product labels. All participants discussed their inability to see as well as they used to and their struggle to read the information provided on cleaning supplies and other household items. The Bottle Monocle (see Figure 2b) attempts to address this problem in an elegant, interesting, and provocative way. Many designs for assisting the elderly (for example, a metal walker) seem institutional, dispassionate, and cold. The Bottle Monocle, by contrast, is colorful and inviting, drawing attention not to the fact that the person's eyes are failing but that the print on the labels is too small for reading.

Participants made clear that the activity of cleaning is for more than just housekeeping. During the course of one interview, a woman lifted her couch with one hand to clean underneath it. She commented that cleaning provided exercise and was a preferable alternative to the gym, especially in the winter. The Calorie-Counter Trigger (see Figure 2c) plays with this notion, drawing attention to the role of household tasks in an exercise routine that maintains health.

These designs actively put technology in the context of everyday life and its cultural history, rather than in the context of other technology. Although Trigger Spray Bottles does not use computing technology, it raises issues relevant to ubiquitous computing. Most people think of ubiquitous computing as a wholly new kind of technology, but it's actually a continuation of a long, controversial history of technology in the home. Ubiquitous devices live alongside many items of everyday technology and share physical space and time with a wide variety of other tools, objects, and tasks. This suggests that the design of ubiquitous devices can draw from other everyday technologies, whether historical, contemporary, or speculative. Book Bottles, for example, can serve as an analogue for computing at your fingertips—accessible when and where you need it but unobtrusive the rest of the time.

Our work acknowledges that people are the experts of their own personal experience. We hope to provide additional frameworks to enrich, reflect, and change that experience.

Culturally embedded computing uses current design practices as a form of social research. Starting with constructs such as participatory design, we learn not only about the technology or the people using it but also about the culture, society, and people from which the design construct originated. Understanding the process of creating designs is a powerful methodology for analyzing society and assumptions because the process of design is about making choices, and these choices suggest the need to explain the basis of those decisions. Our work acknowledges that people are the experts of their own personal experience. We hope to provide additional frameworks to enrich, reflect, and change that experience. This support for reflection includes user studies and devices that support particular experiences.

We identified several strategies at play across the projects that honor this role of participant as expert. First, as designers and researchers, we must approach our interactions with empathy and with a sincere objective to learn, not analyze. Second, establishing peer relationships with people necessitates creating space for diversions: listening to people, inviting questions, and exploring familiar activities that people would feel comfortable talking about and reflecting on. Finally, we must not only create technology designs that give people pleasure but must also craft user studies that people enjoy participating in. Because our project designs seek to balance the effort put into technology with the effort returned by technology, successful user studies should leave participants feeling as enthusiastic or inspired as the researchers and designers.

To put it simply, if we ask someone to report on the role that switches play in their lives, and to take photographs and notes of switches and draw pictures of them, then afterwards that person will see switches, and hopefully other technologies, in a different light. We acknowledge, embrace, and design for that effect. P

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the AUTHORS

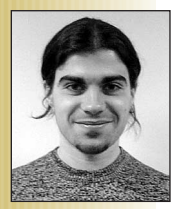
Phoebe Sengers is an assistant professor in Information Science and Science & Technology Studies at Cornell University, where she leads the Culturally Embedded Computing Group. Her research interests focus on critical technical practices integrating HCI with cultural studies. She received a PhD in artificial intelligence and cultural theory from Carnegie Mellon University. She is a member of the ACM, SIGCHI, SLS, SHOT, and 4S. Contact her at Cornell Information Science, 301 College Ave., Ithaca, NY 14850; sengers@cs.cornell.edu.

Joseph (Jofish) Kaye is a graduate student in the Culturally Embedded Computing Group at Cornell University, working on building technology for intimate communication at a distance. His research interests include technology for domestic spaces and the use of scent for ambient-information displays. He received an MS in media arts and sciences from MIT. He is a member of the ACM and is cochair of Cornell SIGCHI. Contact him at Cornell Information Science, 301 College Ave., Ithaca, NY 14850; jofish@cornell.edu.

Kirsten Boehner is a PhD student in the Human-Computer Interaction Group at Cornell. Her research interests include social ambient interfaces, museum installations, and design for reflection and creativity. She received an MS in communications from Cornell University. Contact her at Cornell Information Science, 301 College Ave., Ithaca, NY 14850; kab18@cornell.edu.

Jeremiah Fairbank is pursuing an MS in computer graphics at Cornell University. His research interests include extreme user-centered design, the integration of humanistic perspectives with new technology design, and the perception of homes of the future. He received a bachelor's degree in architecture from Cornell University. Contact him at 934 Stewart Ave. #31, Ithaca, NY 14850; jaf25@cornell.edu.

Geri Gay is a professor in Communication and Information Science and the director of the Human-Computer Interaction Lab at Cornell University. Her research interests include design of interactive media and social interactions online. Specifically, she examines social navigation issues, affective presence, mental models and cognition, information visualization, and mobile computing. Contact her at Cornell Information Science, 301 College Ave., Ithaca, NY 14850; gkg1@cornell.edu.



Yevgeniy Medynskiy is pursuing a BS in computer science at Cornell University. His research interests include HCI and culturally embedded computing. He is working with Cornell's Human-Computer Interaction Group and is a member of the Culturally Embedded Computing Group. Contact him at Risley Residential College #0217, Cornell Univ., Ithaca, NY 14853; ym66@cornell.edu.

Susan Wyche is pursuing an MS in design and environmental analysis at Cornell University. She integrates ethnographic and historical approaches into product design, especially for the home and involving issues of age and gender. She is a member of the Culturally Embedded Computing Group. Contact her at Cornell Information Science, 301 College Ave., Ithaca, NY 14850; spw23@cornell.edu.